UNIX®

RESEARCH SYSTEM

PAPERS

Tenth Edition

Volume II

Computing Science Research Center
AT&T Bell Laboratories
Murray Hill, New Jersey

PREFACE

This selection of supporting papers to accompany the Programmer's Manual reflects both continuity and change in the UNIX research system since the last such collection appeared in the seventh edition a decade ago. Three-fourths of the papers are completely new, and many of the rest have been substantially rewritten. Most of the papers represent the work of members of the center where the system was born, Computing Science Research at AT&T Bell Laboratories. Previous work of this center has become so widely known that many of the more basic papers from the seventh edition could safely be dropped to make way for more recent material.

Some papers continue important themes that date from the early days of the system: software tools, program development, text processing, document preparation. Some address the down-to-earth subject of the care, feeding, and protection of a multifaceted system in an imperfect world. Others address the increasingly pervasive theme of communications and distributed computing: 'stream' connections among processes and files on one or more computers, cross-machine file systems, multiplexed (windowed) terminals, worldwide electronic mail. A few papers suggest the breadth of research applications that meet and reinforce each other in this system: music, graphics, protocol verification, image processing.

Here one can find more up-to-date information about the popular *troff* family of typesetting software than in any other published work. One may also see, in the diverse styles of the several authors, various ways to exploit *troff* and some of its newer rivals. In the useful index by Lorinda Cherry and the playful *pico*-portraits by Gerard Holzmann, one may enjoy some unusual outputs from UNIX tools.

Besides the authors of the individual papers, many other people have helped to bring the tenth edition system into being. They are acknowledged in the preface to Volume 1. The manual is dedicated to the memory of the late Lee McMahon, whose influence pervades the system's approaches to text processing and data networking.

A. G. Hume
M. D. McIlroy
January, 1990

Lee McMahon

Table of Contents

intro Introduction. *A. G. Hume.* 1
Supplementary material for the Research UNIX® system.

Document Preparation

ms Typing Documents on the UNIX System: Using the -ms and -mcs Macros with Troff. *L. L. Cherry and M. E. Lesk.* 7
The basic *troff* macro packages: the -ms document style is useful for most purposes, and -mcs handles Bell Labs cover sheets.

pm The -mpm Macro Package. *B. W. Kernighan and C. J. Van Wyk.* 21
Describes the -mpm macros, a version of -ms that does automatic page balancing.

eqn Typesetting Mathematics — User's Guide. *B. W. Kernighan and L. L. Cherry.* 25
Describes *eqn*, an easy-to-learn language for doing high-quality mathematical typesetting.

tbl Tbl — A Program to Format Tables. *L. L. Cherry and M. E. Lesk.* 35
A program to permit easy specification of tabular material for typesetting. Again, easy to learn and use.

pic Pic — A Graphics Language for Typesetting. *B. W. Kernighan* 53
A language for describing line drawings. *Pic* descriptions included in manuscripts make high-quality drawings when typeset.

ideal Ideal — A Picture-specification Language. *C. J. Van Wyk* 79
This relative of *pic* specifies pictures with constraints and equations. Although harder to use than *pic*, it supports generalized pens, region filling and opaqueing.

grap Grap — A Language for Typesetting Graphs. *J. L. Bentley and B. W. Kernighan.* 109
Converts numerical data into beautifully typeset graphs and charts. Instructions to *grap* may be included in any manuscript.

dag Dag — A Program for Drawing Directed Graphs. *E. R. Gansner, S. C. North, and K. P. Vo.* 147
Given the connection list (and labels) for a graph, *dag* generates an uncluttered layout for typesetting.

prefer Formatting References with Prefer. *M. A. Derr.* 163
Prefer, the modern replacement for *refer*, replaces symbolic citations in a text with properly sequenced bibliographic references and prepares a bibliography.

cip Cip User's Manual: One Picture is Worth a Thousand Words. *S. A. Browning.* 175
How to interactively draw *pic* pictures for your documents on a screen instead of programming them.

troffref Troff User's Manual. *J. F. Ossanna and B. W. Kernighan.* 187
The basic text-formatting program.

trofftut A Troff Tutorial. *B. W. Kernighan.* 223
An introduction to *troff* for those who really want to know such things.

monk Typing Documents on the UNIX System: Using Monk 0.6. *S. L. Murrel and T. J. Kowalski.* 239
How to format documents with *troff* without ever writing *troff* code.

latex Latex User Guide. *H. Trickey.* 259
Local variations to the Latex book.

Programming

mk Mk — A Successor to Make. *A. G. Hume.* 269
The best tool for making sure that large programs are properly compiled with minimal effort.

rc Rc — A Shell for Plan 9 and UNIX. *T. Duff.* 283
The next stage in symbolic shells.

snocone The Snocone Programming Language. *A. Koenig.* 297
A SNOBOL with syntactic sugar.

f77 A Portable Fortran 77 Compiler. *S. I. Feldman and P. J. Weinberger.* 311
Details about the local Fortran.

cin The C Interpreter: A Tutorial for Cin Version 0.18. *T. J. Kowalski, H. H. Goguen, and J. J. Puttress.* 325
A surprisingly effective approach to C. Interpreted code can be combined with compiled code for both flexibility and speed.

pi The Feel of Pi. *T. A. Cargill.* 335
How to use an amazing multi-window debugger for C programs.

Supporting Tools and Languages

yacc Yacc: A Parser Generator. *S. C. Johnson and R. Sethi.* 347
Converts a BNF specification of a language and semantic actions written in C into a compiler for the language.

lex Lex — A Lexical Analyzer Generator. *M. E. Lesk and E. Schmidt.* 375
Creates a recognizer for a set of regular expressions; each regular expression can be followed by arbitrary C code which will be executed when the regular expression is found.

sed Sed — A Non-interactive Text Editor. *L. E. McMahon.* 389
A variant of the editor for hands-off processing in a single pass.

sam The Text Editor Sam. *R. Pike.* 399
The design and use of a remarkable programmable editor with a slick mouse interface.

pico Pico — A Language For Composing Digital Images. *G. J. Holzmann.* 423
A sophisticated, programmable transformer of digitized pictures.

spin Spin — A Protocol Analyzer. *G. J. Holzmann.* 429
A small and powerful tool for the analysis of distributed systems.

anim A System for Algorithm Animation. *J. L. Bentley and B. W. Kernighan.* 451
A system for displaying data that varies over time. Outputs include an interactive viewer and snapshots for inclusion in a *troff* document.

music Computer Music Under the 10th Edition UNIX System. *T. J. Killian.* 477
Programs that convert ASCII to audio.

raster The 10th Edition Raster Graphics System. *T. Duff.* 483
How to make, process, and display high quality color images.

Implementation and Maintenance

setup Setting Up a Research UNIX System. *N. Wilson.* 497
How to configure your system and get it running.

streams A Stream Input-Output System. *D. M. Ritchie.* 503
The way data is passed among processes and communication devices.

netb A Look at the Ninth Edition Network File System. *S. A. Rago.* 513
Details of the current network file system protocol for Research UNIX.

ipc Interprocess Communication in the Ninth Edition UNIX System. *D. L. Presotto and D. M. Ritchie.* 523
A description of the current IPC system; both the underlying system primitives and the user-level code.

authmgr Authmgr — An Authentication Service for Datakit. *D. Cohrs.* 531
A Datakit service for authenticating users.

security UNIX System Security. *F. T. Grampp and R. H. Morris.* 543
How the bad guys can get you if you don't watch out.

upas Upas — A Simpler Approach to Network Mail. *D. L. Presotto and W. R. Cheswick.* 557
How the mail system is organized and how it deals with networks.

uucp Uucp Administration. *D. A. Nowitz.* 563
How *uucp* works, and how to administer it.

fsck Fsck — The UNIX File System Check Program. *T. J. Kowalski.* 581
Semi-automatic diagnosis and repair of UNIX file systems.

backup The File Motel: An Owner's Manual. *A. G. Hume.* 593
The design and maintenance of the 10th Edition incremental file backup system.

lp A Guide to the Lp Printer Spooler. *P. Glick.* 603
The intricacies of running your printers.

index Index. *L. L. Cherry.* 609
An almost mechanically generated index.

Introduction

Andrew G. Hume

AT&T Bell Laboratories
Murray Hill, New Jersey 07974

1. Introduction

This volume contains reports, papers and manuals that supplement the manual pages in Volume 1 of this manual. The selection criteria are not well defined but include utility, general interest, and unavailability in the published literature. Some authors were cajoled into writing papers specially for this volume; otherwise, the papers were chosen from the existing literature, both external and internal to Bell Laboratories. (Most existing papers and reports were extensively revised for this volume.) Accordingly, several papers (such as the *Uucp Administration* paper) do not match exactly the software in the current system. The online manual pages should be consulted before depending on any specific details contained in any of the papers in this volume.

The documents here are grouped roughly into the areas of programming, language tools, document preparation, and system maintenance. Many documents from the last Volume 2 (Seventh Edition, 1979) have been dropped. Some are simply obsolete; others, particularly the introductory papers, have been superseded by better and more up to date books on the UNIX® system. The volume has not shrunk; for every paper that has been dropped, a new program or paper has appeared.

2. Production

The papers in this volume have not simply been reprinted. Most have been converted to use the *mpm*(7) macros (see the *mpm* paper). The rest of the papers use *monk*(1) or *tex*(1). The papers use a two column format except when liberal use of full-width displays make this inappropriate. This not only makes the volume look better; it also makes it about 100 pages thinner.

The papers also try to follow Volume 1 in the typographical representation of names. That is, programs referred to by name are in italics and are capitalized when starting a sentence (like any other noun). Literal filenames, program fragments and things the user would type are in typewriter font. As far as possible, typographic flourishes are eschewed, so that LaTeX is rendered as Latex. Long lines broken for readability use ↵ to indicate the breaks:

```
this is one line which has ↵
been broken because of the column ↵
width
```

Most papers needed significant editing to conform to this standard; some of the larger older papers were not changed.

The layout chosen for this volume implies that all papers must have an even number of pages. Where necessary, papers have been extended by digitized photographs transformed by Gerard Holzmann using *pico*. A few photographs were chosen for sentimental and historical reasons; the rest were chosen mostly for aesthetic appeal from photographs at hand with a slight bias towards the authors of papers in this volume.

The index was produced mechanically by Lorinda Cherry using a small amount of hand editing and a considerable amount of software; details are given as a preamble to the index. Our Center's venerable Linotron 202 typesetter is being retired; the camera-ready copy for this manual was prepared on a Linotronic 200P PostScript printer running at 1270 dpi.

3. A Selected Bibliography

During the fourteen years since a volume of "Documents for use with UNIX" was first gathered for the sixth edition of the *UNIX Programmer's Manual*, the system has grown, and so has its literature. In selecting the contents for this volume, we have omitted topics such as software design and the use of programming languages; good books on these are available elsewhere. A list of the more important books follow. For references on other special languages see *langs*(1).

3.1. General

Kernighan, B. W., & Pike, R. (1984). *The UNIX Programming Environment*. Prentice-Hall.

How to exploit the facilities of the system: utilities, shell, and system calls. Written for programmers; intended for novices but yet also contains nuggets for experts.

Lomuto, A. N., & Lomuto, N. (1983). *A UNIX Primer*. Prentice-Hall.

Written for nonprogrammers; readable and authoritative. Stresses text processing.

Prentice-Hall. (1987). *UNIX System Readings and Applications*. Prentice-Hall. 2 volumes.

Papers reprinted from special issues of the *Bell System Technical Journal*, August, 1978, and October, 1984. Includes classics on the design and history of the system in its many incarnations at Bell Laboratories.

Nemeth, E., Snyder, G., & Seebass, S. (1989). *UNIX System Administration Handbook*. Prentice Hall.

A comprehensive guide to administering your UNIX system.

3.2. C Programming

Kernighan, B. W., & Ritchie, D. M. (1978). *The C Programming Language*. Englewood Cliffs, NJ: Prentice Hall. 1st Edition.

The bible for the classical language and how to use it.

Kernighan, B. W., & Ritchie, D. M. (1988). *The C Programming Language*. Englewood Cliffs, NJ: Prentice Hall. 2nd Edition.

The new testament covering the new American National Standard dialect of C.

Harbison, S. P., & Steele, G. L. Jr. (1987). *C, A Reference Manual*. Prentice-Hall.

The most exact description of what C really was before the American National Standard.

Stroustrup, B. (1986). *The C++ Programming Language*. Addison-Wesley.

A major, largely compatible, "object-oriented" extension to C that incorporates user-defined types and operations.

Computer and Business Equipment Manufacturers Association. (1989). *American National Standard for Information Systems — Programming Language C*. Washington: Computer and Business Equipment Manufacturers Association. X3.159-1989.

The future Talmud.

3.3. System Manuals

(1983-84). *Unix Programmer's Manual*. Holt, Reinhart and Winston. 2 volumes. Also McIlroy, M. D., & Kernighan, B. W. (Eds.). (January 1979). *Unix Programmer's Manual, Seventh Edition*. Murray Hill, NJ: Bell Laboratories. Republished by Holt, Reinhart and Winston.

The seventh edition of this manual. Volume 2 contains more discursive papers on the use and implementation of *adb*, *bc*, *cc*, *dc*, *lint*, *m4*, *make*, *ratfor*, *sed*, and other facilities.

Computer Science Division, University of California. (June, 1981). *Unix Programmer's Manual, Virtual VAX-11 Version*. Berkeley: Computer Science Division, University of California.

The Berkeley descendant of the seventh edition. Volume 2C contains descriptions of *vi* and *Franz Lisp*.

AT&T Customer Information Center. (April 1984). *System V Interface Definition*. P.O. Box 19901, Indianapolis 46219: AT&T Customer Information Center. Select code 307-127.

The official description of what makes a commercial offering qualify as a UNIX system.

IEEE (1988). *IEEE Standard Portable Operating System Interface for Computer Environments (Std 1003.1-1988)*. IEEE.

A vendor-neutral standard for UNIX-like operating system functionality.

3.4. Implementation

Bach, M. J. (1986). *The Design of the UNIX Operating System*. Prentice-Hall.

How System V works.

Lefler, S. J., McKusick, M. K., Karels, M. J., & Quarterman, J. S. (1989). *The Design and Implementation of the 4.3 BSD UNIX Operating System*. Reading, Mass: Adison-Wesley.

How the other half lives.

Equ nent Manufacturers
erican National Standard
- Programming Language
an Business Equipment
X 59-1989.

mmer's Manual. Holt,
vol es. Also McIlroy,
. (E .). (January 1979).
l, Seventh Edition. Mur-
atories. Republished by

thi manual. Volume 2
e papers on the use and
, b cc, dc, lint, m4,
ther cilities.

University of California.
mm 's Manual, Virtual
Co puter Science Divi-
ia.

t of the seventh edition.
scrip ons of *vi* and *Franz*

on Center. (April 1984).
tion P.O. Box 19901,
T C tomer Information
7.

of hat makes a com-
as a NIX system.

ard Portable Operating
ute Environments (Std

rd for UNIX-like operat-

D ign of the UNIX
Hal

I. K Karels, M. J., &
Th Design and Imple-
UNIX Operating System.
ley.

3.5. Special Languages and Applications

Aho, A. V., Kernighan, B. W., & Weinberger, P. J. (1988). *The AWK Programming Language*. Reading, Massachusetts: Addison-Wesley.

Suggestive examples of how to exploit an unusual language.

Harper, R., Milner, R., & Tofte, M. (May 1989). *The Definition of Standard ML, Version 3* (ECS-LFCS-89-81). Dept of Computer Science, Edinburgh University.

An elegant interactive language based on the latest theory of higher level types.

Becker, R. A., & Chambers, J. M. (1984). *S, An Interactive Environment for Data Analysis and Graphics*. Wadsworth.

Just what the title says it is.

Fox, P. A. (1984). *PORT 3*. Murray Hill, NJ 07974: Computing Information Library, AT&T Bell Laboratories. 2 volumes.

A comprehensive library of Fortran subroutines for approximation, ordinary and partial differential equations, linear algebra, optimization, quadrature, special functions and FFTs.

Knuth, D. E. (1986). *The TeXbook*. American Mathematical Society & Addison Wesley.

A modern alternative to *troff* and *eqn*, by the master of computer science.

Lamport, L. (1986). *LaTeX: A Document Preparation System*. Reading, Massachusetts: Addison-Wesley.

LaTeX is to *TeX* as `-ms` and *refer* are to *troff*.

Bolsky, M. I. (1985). *The vi User's Handbook*. Prentice-Hall.

At 66 pages, one of the shorter descriptions of this big, yet popular, program.

AT&T Customer Information Center. (1982). *UNIX System V Writer's Workbench Software Release 2.0 Documentation Set*. P.O. Box 19901, Indianapolis 46219: AT&T Customer Information Center. Select code 302-949.

Complete detail about *wwb*(1).

Stevens, W. R. (1990). *UNIX Network Programming*. Prentice Hall.

A UNIX programmer's guide to using IPC and networks.